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Interactive Learning Application in Microbiology: The Design, Development and Usability

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Abstract

Traditional forms of lecturing have been used in universities and schools for hundreds of years. It is one of the methods of teaching, due to the fact that the message is delivered across a huge number of students at the same time. However, there are serious questions regarding the effectiveness and student's engagement of this conventional lecture approach because studying and memorizing the concepts from the teachers' note is considered as an ineffective way of teaching. Presently, there are many calls to move away from the conventional lecture to interactive computer learning systems that allow students to gain a thorough understanding about a certain topic or subject. Instead of being bounded by these limitations, multimedia applications open up a new world of discovery in learning. This Interactive Microbiology application will imply the interactive learning prospect that allows the incorporation of animation, moving pictures, sounds and quizzes which extend the ability to present materials that encourage student's interaction with the subject matter. The objective of the project is to design and develop an interactive learning application to assist students for the Microbiology subject. 30 students were selected as the target users for this project whose reaction and opinions have been analyzed and evaluated.

Selection and/or peer-review under responsibility of the Faculty of Education, University Technology MARA, Malaysia.

Keyword: Interactive Learning; Multimedia; Microbiology; Biotechnology; Recombinant DNA

1. Introduction

Teaching tools begin to convert from simple text to interactive media with the development of technology, potentially enabling a more thorough approach in learning. Specifically, the addition of multimedia may help in reducing the difficulty of converting text into practice because it offers a visual demonstration of instructions.

This is concurrent to the fact that students respond to information differently. Thus, teachers will often use many different formats and modes to teach the subject matter of a lesson. This is why teachers normally apply some combination of lecture, text revisions and hands-on laboratory tutorials to convey information. Nowadays,

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with the advent of the technology, teachers acquire several new and exciting ways of interactive learning to present information to the students. The interactive learning allows the integration of animation, text, and moving pictures into lessons, which amplify the abilities to present materials that encourage students' interaction with the subject matter. Pictures and animations visualize a dynamic phenomenon or processes that cannot be readily seen by the human eye and the multimedia allow students to be more active in learning. They can watch microorganisms up close, navigate pages through buttons and repeat the steps of the particular process.

The objectives of the project are to design and develop an interactive learning application to assist students for Microbiology subject and to test the usability of the system for learnability, memorability, simplicity, satisfaction and overall reaction to the application.

The focus of this project is to develop interactive learning application in Microbiology course. The scope of the project will cover one topic from Microbiology (BIO461) course which is Microbiology and Recombinant DNA. The target audience of this project is mainly the students from AS201, Bachelor in Science (Hons) Biology program in Faculty of Applied Sciences at University Teknologi Mara, Shah Alam.

2. Literature Review

Book-based learning is one of the conventional learning environments where students take notes and teachers give lectures. Traditional lectures and textbooks basically involve only one-way of communication which is from instructor to students (Preszler et al., 2007).

Few students are able to learn better in the traditional structure of university science courses and as a result, universities are producing graduates who are unable to apply a meaningful understanding of science subjects. According to Gregory and Chow (2008), it was recognized that students must be able to understand the basic concepts in biology particularly those found in Microbiology. A major challenge to biology educators is to teach these processes so that students can comprehend and understand their complexity (McClean et al., 2005). Based on McClean et al. (2005) which had conducted similar research on the topic of Biology, student which heard lecture augmented with the animation followed by an individual study with application produced significantly better result.

In addition, this subject required a lot memorizing process where some students are not good in memorizing and they need some tools to help them to memorize. Many students find that the Microbiology course is quite difficult to learn, understand and memorize especially the concepts and the processes. According to Amirruddin (2007), studying and memorizing information from the text books and teacher's notes are no longer an effective way to gain a thorough understanding about a certain topic or subject.

2.1. Behaviourism Learning Theory

Behavioural Psychology is mainly concerned about how a person's behaviour results from the stimuli both in the environment and within themselves which then allows the researchers to utilize the results to learn a great deal about their behaviours, the effect of environment towards them, how they learn new behaviours, and what motivates them to change or remain the same.

Reinforcement is one of the components in behaviourism theory. It is any event that strengthens the behaviour it follows. There are positive reinforces which include positive punishments and negative reinforces which include negative punishments. Positive reinforcement is favourable events that are presented after the behaviour which the response or behaviour is strengthened by a praise, a gift or reward. Negative reinforcement involves the removal of an unfavourable event after the display of behaviour which the response is strengthened by the removal of something considered unpleasant. In general, reinforcement's consequences strengthen the behaviour that led to it, and it weakens that behaviour by punishment (Staddon & Niv, 2008).

An example is a quiz that involves reinforcements where once the user enters the correct answer, praise will be given such as "Congratulations. Good works" but if the user enters the wrong answer, unfavourable event will occur such as a deduction of marks or repeat the level again. This method is important to keep the user motivated

because according to Weiss and Rosen (2010), learning is done by means of conditioning and reinforcement that create a positive or negative motivation to learn.

2.2. Cognitivism Learning Theory

Cognitivism is a study of mental processes including how people think, perceive, remember and learn. The main focus of cognitive psychology is on how people acquire, process and store information. Matthews et al. (2009) stated that according to Mayer, The cognitive theory of multimedia learning includes three cognitive science principles which are human processing information, limited capacity assumption and active processing assumption. In cognitivism, prominent figures such as Bruner, Piaget and Papert give attention to the concept as follows (Simonson et al., 2003):

- How knowledge is arranged and structured.
- Whether students are ready to learn or not.
- Give importance to intuition and intellectuality.
- Motivation and positive outlook on learning.

This theory will be implemented in the development process which would determine how the content will be structured and displayed. The topics of Microbiology will be systematically arranged so that students can learn effectively and can store information in the long-term memory. The students who attend the course of Microbiology have the possibilities to make their own thinking and presentations that are published in the interactive learning environment (Dineva, & Nedeva, 2009).

2.3. Learning Approach

Many science teachers use animation to help students to understand complicated science topics (Hooft & Denzer, 2010). The animation simplifies the complexities of the concepts and processes in molecular genetics, by enabling students to observe the dynamics, either as a whole or step by step, and take part in interactive activities, such as taking an active part in DNA replication, transcription and translation processes (Rotbain et al., 2007).

Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts (Novak & Canas, 2008). By using concept maps as an assessment tool, it can promote learner's self-assessment and support the teacher by improving the learning course through systematic assessment of learner's knowledge and analysis of its results (Vilkelis et al., 2008).

A quiz can be beneficial to students for many reasons which can help students maintain focus and develop essential problem-solving skills. Quizzes can discover the scope and depth of student's knowledge and offer an opportunity to the students to demonstrate what they have taught (Rao et al., 2002).

According to Santrock (2006), there are several guidelines in choosing and using technology:

- Choose technology that can help students actively explore, construct and restructure information.
- Choose technology that presents positive models for students by monitoring technology for equity in ethnicity and culture.
- The teaching skills are critical, regardless of the technology you use. Technology becomes efficacious only when you know how to use it, present it, guide and monitor its use and merge it into a larger effort to develop students who are motivated to learn, actively learn and communicate effectively.
- Continue to learn about technology and increase technological competence. Digital technology is still changing at an amazing pace. It is good to keep up with the technology advances and gain more skills.

3. Methodology

Methodology is usually a guideline system involved in problem solving with specific components required such as tasks, phases, techniques or tools.

3.1. Project Framework

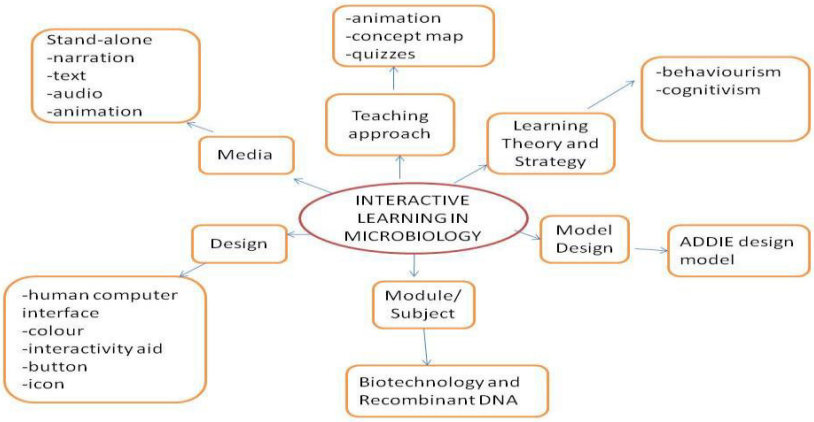

Fig. 1. Project Framework

The framework in Fig 1 described briefly about overall development of the project which consists of subject involve, learning theory, teaching approach, multimedia elements, interface design and model design.

3.2. ADDIE Model

This project used ADDIE model as a methodology for developing an interactive learning application in Microbiology. ADDIE design model consists of five phases which are analysis phase, design phase, development phase, implementation phase and evaluation phase. Baharuddin et al. (2006) stated that they chose ADDIE model because ADDIE model is systemic, systemic, reliable and empirical.

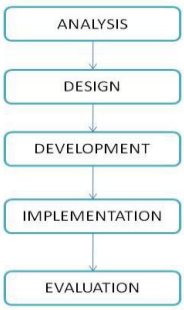

Fig. 2. ADDIE Model

Analysis phase is the most important phase in ADDIE model. This phase involves identifying the problem statement, project scope, project goal and objectives, targeted audience and learning environment and learners existing knowledge and skills are identified. During this phase, defining and developing involve a clear understanding of the audience's needs and constraints, existing knowledge, skills, and the desired outcome of the project.

Design is concerned with subject matter analysis, lesson planning and media selection. In this phase, multimedia element will be used wisely. This phase involved the complete design of the learning solution. During this phase, there are certain points that should be considered:

- Choosing the most appropriate media by identifying the knowledge and skills required to build the application.
- Determine appropriate interaction which should consider the design principle, look and feel, user interface and content.

Most of the design, images, biology diagrams and button image were done in Adobe Photoshop CS3. This is because Adobe Photoshop CS3 holds many features and utilities that make manipulation of image and picture easier.

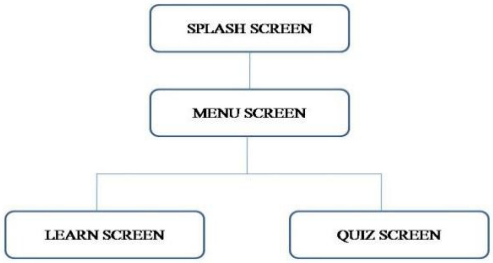

Fig. 3. Main Screen

No	Screen Name	Function
1	Splash	This screen is act as a welcome page with the title. It might play some music.
2	Menu	This screen contain subtopic of the subject. User can choose among several options.
3	Learn	This screen allow the user to start the learning process.
4	Quiz	This screen is where exercise take place to enhance user understanding more.

Fig. 4. Function of Main Screen

There are four main screens in Fig 3 for interactive Microbiology application. Each screen serves a different function inside the application and provides distinctive purposes as shown in Fig 4.

The development phase involves creating or obtaining any media mentioned in the design of the courseware. It concerns the actual production of the design specifications. It is to develop application according to the framework specification. Most of the development project involves the usage of Adobe Flash Profesional CS5 where Adobe Flash Professional is among the most popular tool for e-learning applications. Actionscript 3.0 is used rather than Actionscript 2.0 because it contains many new features and a great deal of performance that were not available in the previous versions.

Fig 5 shows that this project starts with designing the application in Adobe Photoshop software. After that, all images were imported into Adobe Flash library. The narration feature took place in NaturalReader 9 software which is then saved as .mp3 format. Quiz was created in QuizCreator and saved as .swf format.

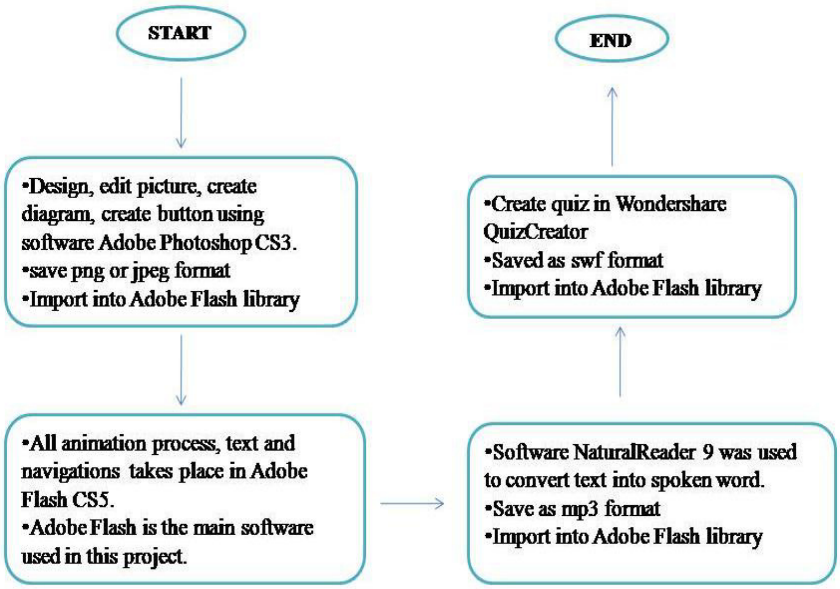

Fig. 5. Project Development Flow

The implementation phase is where the application development is administered to the target user. Testing will be in the context of learnability, simplicity, memorability, satisfaction and overall reaction towards the application. This phase is important to detect minor errors and to test whether the application is working properly. Any errors will be recorded and fixed.

Evaluation phase is the phase which decides whether the course is effective and satisfies the project objectives. This is also the phase to get the feedbacks from the users who are involved during the development and delivery of the project. The completed application will be distributed to the 30 target users. The Microbiology application was burned into CDs and the paper questionnaires were warped with envelope which is then distributed to 30 target users. They will be given time to test the application and answer the questionnaire.

3.3. Screenshots

Upon the completion of the Microbiology application, it had been tested and was deemed as working smoothly. The screenshots of application flow are as below.

Fig. 6. (a) Welcome page; (b) Homepage

Fig. 6 (a) shows the welcoming page before the users enter the homepage of the application. Fig. 7 (b) is the homepage of the project. It contains the title of the Microbiology topic and three buttons which are the subtopics of the subject. This page also contains quiz button for user to test their knowledge. User can click any subtopics button they interested.

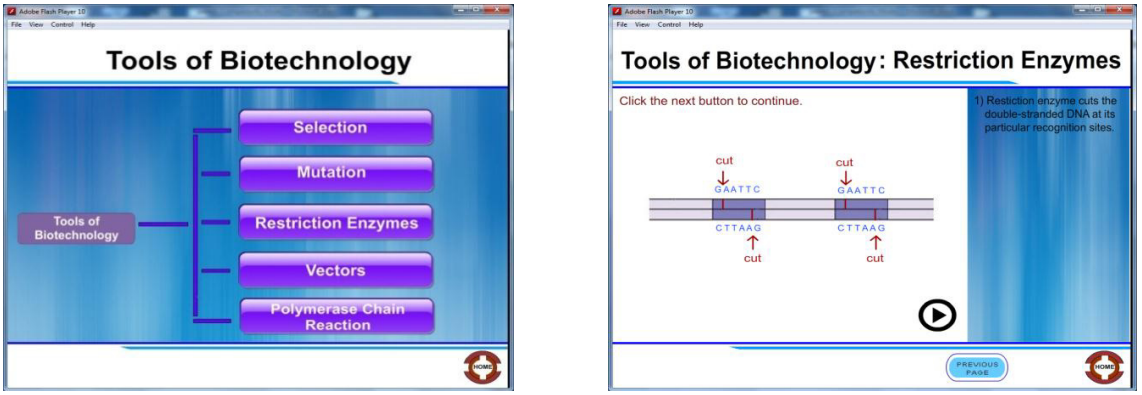

Fig. 7. (a) Subtopics page; (b) Content page

When a subtopic button, tools of biotechnology button, is clicked, the output will be seen as similarly shown in Fig. 7 (a). There will be five subtopic buttons of Tools of technology and the home button to go to the homepage. Some of the subtopic pages are shown in Fig. 7 (b) contains explanations and diagrams in a step by step process with voice aided. The next button is to navigate to the next step. At the end of the lesson there will be a concept map on the particular subtopics.

However, there are few weaknesses of this Microbiology application that was discovered. Some of the biology terms may not be articulated well and clearly using Natural Reader software thus the pronunciations might not be exact and fluent. The application was saved in .swf format which may require installation of certain plug-in to run the application.

4. Evaluations and Discussions

The formative evaluation has been carried out using paper based questionnaire presented to the target users who are UiTM students who will take the program Bachelor in Science (Honours) Biology with program code AS201.

30 students of target users were chosen for the survey testing and all of them are female and have the age range between 20-24 years old. These paper based questionnaires was printed and the Microbiology application were burned in the CD for 30 students. Each one received one CD and one paper of questionnaires which is warped with an envelope and were brought to their room or house to test the application. After five days, all questionnaires were collected and evaluated.

The SPSS software was used to evaluate the questionnaire. The SPSS is a statistical package for Social Sciences. It was designed to perform statistical analysis data which is used for complex calculations in analyzing numerical data.

The testing was conducted to evaluate the usability of the application in terms of learnability, memorability, simplicity and satisfaction. Learnability aspect is to test the content of the Microbiology subject, whether the content suit with the objective learning or not. Memorability aspect is to test whether the application can help the users to remember the steps and term in Microbiology subject easily or not. Simplicity aspect is to test the simplification and the continuity of the user interface. Lastly, satisfaction aspect is to test the attractiveness of the application.

Table 1. One Sample Statistic

	N	Mean	Std. Deviation	Std. Error Mean
Learnibility	30	4.2667	.52083	.09509
Memorability	30	4.1667	.46113	.08419
Simplicity	30	4.1333	.50742	.09264
Satisfaction	30	4.1000	.66176	.12082

In the Table 1 above, the highest mean score among all four aspects is learnability which is 4.27. This means that the target users favour learnability aspect rather than the other four. Almost all the target users agreed that this application helped their lesson process with each lecture well organized, easy to understand, pictures and explanations with a step by step help in learning process and the content suit the learning objective of the subject. This is compatible with the cognitive theory which target users act on information in ways that make the lesson more meaningful.

Memorability comes after learnability as target users can store information in the long term memory in an organized structure related to their existing understanding of the subject matter. Encouraging students to create such structure makes students learn in the best condition which lead to long lasting memory. Simplicity aspect with the mean score of 4.13, agreed that the terminologies used for navigation are intuitive, terms throughout the applications used are consistent, navigation button is handy and user friendly in every page and position of texts and pictures on the screen is consistent. This aspect considered important as it promotes the smoothness of the application delivery.

The lowest mean is satisfaction aspect where some of the users feel that this satisfaction aspect needs to be improved further which involves the design, font text, colour theme that need to be more attractive and layout interface that require to be more visually appealing so that it will motivate the students better.

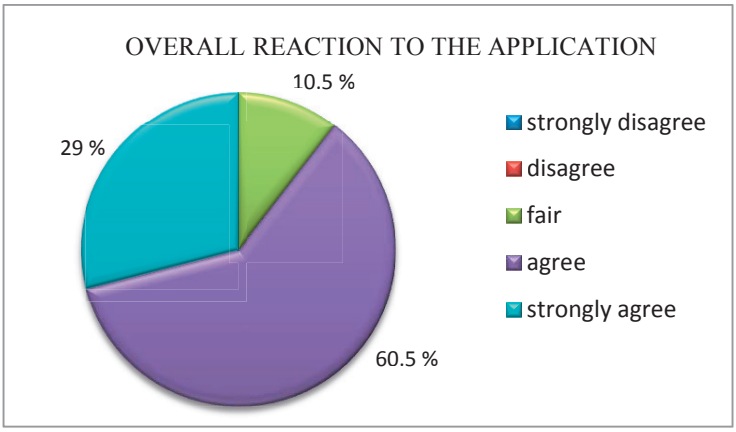

Fig. 8. Percentages of Overall Reaction to Application

The pie chart above was the feedbacks from the target users which consist of strongly disagree, disagree, fair, agree and strongly agree. The highest percentage of the overall reaction is agree statement which is 60.5 % and the lowest will be 0 % for strongly disagree and disagree statement. This can be concluded that most students agreed that the overall reaction to the application is good, some of them strongly agreed that this application is good and 10.5 % of them feel this application is fair.

5. Conclusion and Recommendations

The Interactive Microbiology promotes the learning of microbiology by resolving theoretical problems. The application was designed to be used whether in the classroom, as well as for independent learning. Students understand better with the help of animations and moving pictures especially the concept in Microbiology.

Microbiology application still needs to be improved to provide greater content and performance for later improvements. There are few aspects that can be improved for the future advancement for Interactive Microbiology application which the content of the application can be added to increase the understanding of user better and enhancement of the interactive element in the application. Besides, the graphics can be improved by converting from 2D to 3D animation to attract and immerse users to use the application. This application can be run in the computer only. Since mobile learning is now being popular, this application can be transformed into the mobile form to make the learning process more flexible.

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